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FOR

GENERATING ALPHANUMERIC CHARACTERS

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GENERATING ALPHANUMERIC CHARACTERS

Background

[0001] An embodiment of the invention described below relates to a technique for representing alphanumeric characters (such as the letters of the English alphabet) using a set of graphic symbols that may have reduced information content relative to the characters. In addition to other applications, the technique may allow fast and accurate direct manual entry of electronic data into a device that has limited physical space for data entry, such as a personal digital assistant (PDA) with a touch-sensitive display screen. Other embodiments of the invention are also described.

[0002] Small, electronic logic-controlled devices such as PDAs are popular tools for taking notes and communicating with others. They are battery-powered and portable yet can deliver significant computing power and connectivity. Their small size however may preclude a full-size keyboard in which each letter of the alphabet is assigned a large, separate key. Instead, these devices typically have a specialized data input interface, such as a touch-sensitive display screen, with a relatively small area on which an operator draws, using a hand-held stylus, the character that he wants to enter. After the operator makes the drawing on the interface, the device then attempts to interpret the drawing to determine the intended character. Words and phrases can be entered in this manner, without using a full keyboard, provided the device can properly interpret the operator's handwriting. To assist in this process, restrictions are placed on the location in the writing area and the path to take when the user makes a drawing. An example of such a device is the PALM handheld computing device that features the GRAFFITI writing software, by Palm, Inc., Milpitas, CA.

[0003] Although the suggested GRAFFITI drawings bear a strong resemblance to their corresponding characters, the technique often results in the wrong character being detected when the pace of writing quickens. In addition, there is a noticeable delay between the point in time that the user has completed a drawing and when the corresponding character appears before the user.

[0004] Another method for entering alphanumeric data is described in U.S. patent no. 5,982,303 to Smith. That patent describes how a complete set of alphanumeric characters may be entered on a data input device having only nine keys arranged in an array. Each character is input by entering sequential keystrokes which define a pictograph. The patent also alleges that an untrained operator can quickly learn the pictographs which correspond to each character. While some of the pictographs employed bear a vague resemblance to their corresponding alphanumeric characters, most do not. As a result, the operator may be required to spend a significant period of time learning or memorizing the strokes needed to enter most of the characters.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The embodiments of the invention are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" embodiment of the invention in this disclosure are not necessarily to the same embodiment, and they mean at least one.

[0006] **Fig. 1** illustrates a table of a set of character features or building blocks that are in the nature of open and closed plane curves, and how each character can be decomposed into a subset of these curves.

[0007] **Fig. 2**, shows a tentative matrix obtained by assembling the features together based on their relative positions.

[0008] **Fig. 3** illustrates application of the stretched matrix to select a combination of features that represent the letter "b".

[0009] **Fig. 4** depicts a complement matrix.

[0010] **Fig. 5** shows regions of a solid, complement matrix being visually contrasted with the remainder of the matrix to form a graphic symbol for the letter "b".

[0011] **Fig. 6** shows examples of how the matrix-complement approach may be used for forming more complex graphic symbols than necessary, to obtain a more recognizable graphic symbol.

[0012] **Fig. 7** illustrates a set of recognizable graphic symbols that correspond to the 26 letters of the English alphabet and the 10 decimal system numerals, based on a 19-element matrix-complement approach.

[0013] **Fig. 8A** shows how the 19-element complement matrix is overlayed by a 12-element (three column by four row) control matrix.

[0014] **Fig. 8B** depicts a six-point array that can be used instead of a grid, to suggest the fixed locations of the regions of a 12-region control matrix.

[0015] **Fig. 9** illustrates 36 code configurations of the 19-zone complement matrix overlayed with the 12-zone control matrix, highlighting selections of no more than two control zones in each code configuration.

[0016] **Fig. 10A** shows 36 graphic symbols all using the 12-zone control matrix with no more than two zones in each selection, yet still being readily recognizable as the characters they are intended to represent.

[0017] **Fig. 10B** depicts a stylized glyph pictogram that is aligned with its corresponding control regions.

[0018] **Fig. 11A** symbolizes an example process of construction, in the mind of a user, for indicating the letter "K".

[0019] **Fig. 11B** shows in block diagram form a handheld computing device.

[0020] **Fig. 11C** depicts in block diagram form a handheld computing device in which the input control and visualization areas overlap a large portion of the character output display.

[0021] **Fig. 12A** depicts pen-down and pen-up actions by a user, on a touch-sensitive screen, for selecting the regions or zones of a matrix.

[0022] **Figs. 12B-E** illustrate the use of a swirl action on a touch-sensitive screen, for differentiating between characters that share one or more control regions or code configuration.

[0023] **Fig. 13A** illustrates another set of graphic symbols that recognizably represent the 36 alphanumeric characters, while adhering to the matrix complement concept.

[0024] **Fig. 13B** depicts a generic receiving area template for illustrating the symbols of **Fig. 13A**.

[0025] **Fig. 14** shows a word formed as a combination of symbols taken from those in **Fig. 13A**.

DETAILED DESCRIPTION

[0026] An embodiment of the invention is directed to a character representation technique in which each alphanumeric character is represented by a separate, graphic symbol that is designed to be a mnemonic aid to the user. The user, when looking at the graphic symbol, should be able to easily determine or recall which character corresponds to the symbol. In addition, each graphic symbol is easy to remember, because it is designed in such a way as to be suggested by one or more apparent, basic features of its respective alphanumeric character.

[0027] For the user to indicate her desired character, a group of zones may be defined in a writing area or receiving area. Each symbol is designed to suggest to or remind the user of a respective combination of one or more zones, to be selected from the group. The combination of zones for a desired character is defined so that, when visually contrasted with the remainder of the group, the remainder of the group resembles the desired character. Each zone of a given combination may serve to highlight or suggest one or more respective features of the corresponding character, via a complementary rather than direct relationship with that feature. In the following section, a derivation for a set of basic features or building blocks is given, by decomposing each character into one or more of these basic features.

[0028] The character representation technique has been applied to decompose each of the twenty-six letters of the English alphabet and ten decimal numerals, into just a few features taken from a set of nineteen (19) features. This so-called feature-based representation of each character may be used as the graphic symbol for that character. This type of symbol is preferably depicted using a matrix of twelve zones, arranged in four rows and three columns. A motivation for this particular number and arrangement of zones is given below, although it is possible to use other zone arrangements, as well as a different number of zones, for indicating the symbols. For example, a 19-zone matrix (that is a direct result of the 19 basic features) may be used by itself, i.e. without reduction to the 12-zone matrix, to depict the graphic symbols. It has also been found that every one of the alphanumeric characters

may be represented by a respective combination of no more than two zones (even in the 12-zone matrix). This combination is also referred to as a code configuration.

[0029] Due to the relative simplicity of each combination of zones, a user can quickly indicate her desired character by making merely one or two selections on the matrix. Users can be expected to rapidly learn the combination for entering a character, because each combination is easily distinguishable from another and is naturally suggested by the basic features of its respective character. Accordingly, this is expected to allow the user to form entire words and phrases quickly and in a relatively error-free manner. Each indicated combination can be mapped into its corresponding character through a look-up table, thereby allowing low-cost yet fast, electronic decoding of the combinations. This renders the technique particularly effective for data entry in small, electronic logic-controlled devices that do not have a full-size keyboard, although other applications such as paper forms (to be filled in by hand and then scanned electronically) may also benefit from the technique.

[0030] A derivation of the preferred mapping between each combination of one or more zones and its corresponding alphanumeric character may be summarized as follows. First, each character is represented as a juxtaposition of some of a set of open and closed plane curves, also referred to as features or components. These features are like building blocks and may be idealized into rectangles or squares, and angular portions of such rectangles or squares. Other shapes are, however, possible. As explained in detail below, there may be 19 different features needed to compose all of the letters of, for example, the English alphabet and the 10 decimal numerals. Next, a template or matrix is created based on the entire set of features, by abutting the features to each other in such a way that each feature can be visually distinguished from the others. This template may then be overlayed with a smaller, second matrix (e.g. a 12-zone matrix). The second matrix acts as an adapter, to further reduce the number of control regions that will be offered to the user for indicating a character, from 19 to, in this example, just 12. Each character is indicated by a respective selection of one or more (and in most cases, no more than two) regions or zones in a matrix.

Feature-Based Character Decomposition

[0031] **Fig. 1** illustrates a table of a set of character features or building blocks in the nature of open and closed curves. The inventor has found that a complete set of distinct, graphic symbols may be generated, from such a relatively small set of features or building blocks that closely resemble their respective characters. The features are shown in the rows of the table of **Fig. 1**. A set of 36 alphanumeric characters including the letters of the English alphabet (some in lower case while others in upper case) and the ten decimal numerals are listed in a first upper row 122.

[0032] Within the column beneath each character in the first upper row 122 are marked the features, taken from a left hand column 128, that may be deemed necessary and, in most cases, sufficient for recognition purposes. For example, the letter "o" has only a single mark in its column, in the row associated with what is referred to as the on-center, closed curve 131. In a second upper row 124 are all of the corresponding graphic symbols that are composed from the features. The sufficiency or near sufficiency of just those features for recognition purposes can be appreciated. In some cases, slightly different features may be used, or feature nuances may be added, for characters that look similar. For example, "o" and "0" may be represented by an on-center closed curve 131 and a below-center closed curve 132, respectively. In the case of "s" and "5", and "z" and "2", feature nuances may be defined as illustrated in **Fig. 9** to distinguish their selection processes. Note that feature nuances, employing fragments of a feature, may also be used simply to make a graphic symbol more recognizable.

[0033] The features listed in the left hand column 128 may be grouped into three distinct categories, namely (1) closed plane curves, (2) u-shaped plane curves that open up, down, left and right, and (3) right angle shaped plane curves that open out to the four quadrants (upper-left, upper-right, lower-right and upper-left). In such idealized form, as rectangles or parts of rectangles, the curves in these three categories are angular; alternatively, they may be defined using smoother, less angular curves or shapes.

[0034] Note that each feature may be defined not only by its shape and orientation, but also by a relative location. The inventor has found that these 19 features may be sufficient to generate the readily recognizable set of 36 graphic symbols, corresponding to the 36 alphanumeric characters set forth in the first row 122 of the table in **Fig. 1**. Note also that 33 out of the 36 can be characterized with at most two features. And of those 33, 25 of them can be characterized uniquely so that they can be distinguished from the others on the basis of feature decomposition alone. This character representation technique can also be referred to as a modular character construction methodology, where each character can be decomposed into one or more modules. It should be noted that the characters may alternatively be represented by combinations of features other than those listed in **Fig. 1**. Also, a different set of constituent features may be defined, that may be more or less numerous than the 19 shown in **Fig. 1** and that may have different shapes and orientations.

[0035] When decomposing the characters into their constituent features, each character is preferably drawn to fill the same vertical range. Terms like upper or lower (or above-center and below-center) can therefore be interpreted as situating a feature in the upper or lower half of that vertical range.

[0036] The features that are indicated in **Fig. 1** as constituting each symbol may be viewed as meeting a minimum threshold needed to make a character representation recognizable and distinguishable from the other characters. Indeed, a graphic symbol may be defined in a more complex manner, using additional features or nuances. For example, when using only the given set of features shown in **Fig. 1**, some characters may not be readily distinguishable from others, such as "g" and "9", "o" and "0", "s" and "5" and "z" and "2". In addition, to make the letter "v" more recognizable and also distinguishable from the letter "u", "v" may be represented as if it were an upper case "Y" with a very short stem. This provides the effect of the characteristic "v" vertex, thus distinguishing it from the rounder or flatter "u". Other enhancements to make a symbol more recognizable are possible. Some special cases will be addressed below.

The Matrix-Complement Approach

[0037] In addition to discovering that the characters can be decomposed into constituent features, the inventor has also found an effective process for indicating the graphic symbol (and hence the desired character) by a user. First, a template 204 is formed, as shown in **Fig. 2**, by bringing the features close together based on their relative positions (that is upper, center, lower), and their orientation (that is opening to the right, opening to the left, opening upward and to the left, etc.) Features that have an orientation associated with them are located at the outside of the matrix, where the feature can face out in its specified direction.

[0038] Next, almost all of the assembled features are "stretched" so that they abut one another, eliminating the intervening spaces and thereby resulting in a stretched matrix 208 in **Fig. 2**. Note also that the stretched features become the boundaries of the regions in the matrix 208 in such a way that most of the regions line up in rows and columns. The purpose for this will become apparent below.

[0039] **Fig. 3** illustrates application of the stretched matrix 208 to select a combination of features that represent the letter "b", namely the below-center closed curve 132 and the curve opening upward and to the right 146 (see also **Fig. 1**). Note how the features 132, 146 may be selected by the user's manual actions (indicated by the X) upon the corresponding regions (or elements) 232 and 246 of the matrix 208. However, the features, as highlighted in the right-hand diagram of **Fig. 3**, may not easily convey the form of a recognizable character.

[0040] A solution to the above difficulty may be to first provide a rectangular background to the matrix 208, and second, interpret the features as though they partition the background into smaller parts or components. This combination of a rectangular background (having preferably a solid color) that is partitioned into regions or zones, which are delineated in part by basic features of a set of alphanumeric characters, is referred to as a complement matrix 408, depicted in the right-hand diagram of **Fig. 4**. The reason for using the term "complement" will become clear below.

[0041] Next, it is instructive to note what happens when, for example, regions 532 and 546 in the solid, complement matrix 408 are visually contrasted with the remainder of the matrix, as shown in **Fig. 5**. A graphic symbol is formed that bears a strong resemblance to the letter "b". This resemblance may become more apparent when the symbol is viewed from a further distance. This character representation is advantageously achieved without having to juxtaposition the features 132 and 146, as would be needed in **Fig. 3** to recognize that the letter "b" is being sought. The regions 532 and 546 of the matrix 408 are said to suggest the features 132 and 146 (see **Fig. 3**), through a complementary rather than direct relationship with those features.

[0042] It should also be noted that the complement matrix 408 allows a feature of a character to be represented in more than one way. For example, consider **Fig. 6** where the feature of a center curve opening to the right (reference no. 142 in **Fig. 1**) can be recognizably represented by contrasting region 542 with the remainder of the matrix 408. An alternative here is to visually contrast the three regions 542, 540, and 544. The latter combination of regions might yield a more recognizable graphic symbol (in this case representing the letter "c"). **Fig. 6** also shows other examples of the matrix-complement approach for forming more complex graphic symbols than necessary, i.e. the letter "u" (center curve opening upwards 133 suggested by the complement region 533), the letter "L" whose graphic symbol is formed by visually contrasting the complement region 546, and finally the letter "o" whose graphic symbol is formed by visually contrasting the region 531.

[0043] Using the matrix complement technique described above, and sometimes applying multiple compliment regions per feature, a set of recognizable graphic symbols may be generated that correspond to the 26 letters of the English alphabet and the 10 decimal system numerals as shown in **Fig. 7**. The graphic symbols are easily recognized to be the characters they are intended to represent.

[0044] Another way to understand the matrix-complement approach may be as follows. Rather than being directed to a drawing-based approach where the features of a character, or even a mnemonic, are positively recited by the application of force (via a finger or stylus) on a receiving area, an

embodiment of the invention instead indicates each character starting with a matrix of solid elements that are of the same color or material, from which pieces are essentially "removed" by the user applying force to those pieces, when entering her desired character. This leaves behind a graphic symbol (also referred to as a stylized, glyph or glyph-like pictogram) that closely resembles the character. Thus, it is the remainder of the matrix, or the remainder of the group of regions that make up the matrix, which resembles the character, once the selected regions have been removed or visually contrasted in response to user input.

The Control Matrix

[0045] Although in the complement matrix 408 not all rows have the same number of regions, it is possible to overlay a three column by four row array of rectangular regions or zones over the complement matrix 408. In that case, each of the larger elements of the complement matrix 408 may be completely contained in a separate one of the twelve regions. This is illustrated in **Fig. 8A** where the complement matrix 408 is overlayed by a three column by four row control matrix 808.

[0046] The control matrix 808 is intended to be a more efficient means for the user to enter manual actions that indicate a desired character, by the selection of one or more of twelve zones that overlay the elements of the complement matrix 408. Note that the selection zones in the control matrix 808 are fewer and larger than those of the complement matrix 408 and accordingly should be easier for the user to operate.

[0047] To suggest in the mind of the user the fixed locations of the control regions in the control matrix 808, a grid 810 may be displayed. As an alternative to the grid, a six-point array 814 with a visible outside boundary 816 may be displayed, as shown in **Fig. 8B**.

Mnemonic aids

[0048] In a preferred embodiment, at most two selection zones are needed to identify any one of the 36 alphanumeric characters previously mentioned. This embodiment is illustrated in the 36 configurations of **Fig. 9**

where each combines an instance of the 19-zone complement matrix overlayed with the 12-zone control matrix. These regions or zones may correspond to push-buttons on a keyboard or keypad, or to highlighted areas on a touch sensitive surface.

[0049] The 36 configurations shown in **Fig. 9** may also be used as the graphic symbols or mnemonic aids. As an alternative, an otherwise solid 12-zone matrix depicting a respective 2-zone selection for a given character may be used as the graphic symbol for that character. That is because despite having less detail than those based on the 19-zone matrix, graphic symbols that use the 12-zone matrix are still recognizable as the characters they are intended to represent. See, for example, the two-zone representation of each graphic symbol depicted in **Fig. 10A**. Note that the outline or border of each instance of the 12-zone matrix does not appear in that it is of the same color as the background around each matrix.

[0050] As another alternative, a more detailed graphic symbol may be provided to represent a character and to act as the mnemonic aid. More detailed graphic symbols may be used to represent special characters other than those of the alphabet. For example, additional detail may be provided for the graphic symbols that represent the characters "[", "{", and "C" (upper case c), to clearly distinguish the symbol used for the letter "c". The graphic symbols depicted in **Fig. 9** are preferred, because each of them readily maps into and is identified with the regions or zones for their selection. It is believed that this aspect makes it relatively easy for people to remember how to designate a desired character, in the feature-based, complement matrix approach.

[0051] In the preferred embodiment, a graphic symbol (e.g. a stylized glyph pictogram) is made to appear, when the user has selected a given combination of regions from the control matrix that correspond to that symbol. In addition, this symbol is preferably "aligned" with its corresponding control regions. In other words, at least a part of every contrast area (that allows the symbol to be viewed) falls within the corresponding control region that has been selected. For example, in **Fig. 10B**, at least a part of the area 1004 falls

within the selected control region 1014. Similarly, at least a part of the area 1008 falls within the selected control region 1018.

[0052] The preferred relationship between a stylized glyph, as it appears before the user, and its corresponding, selected control regions may also be explained as follows. First, the stylized glyph should be comparable in size to the entire control matrix. Second, the outside boundary of the stylized glyph should be substantially co-extensive with that of the control matrix. Both of these conditions can be seen in the control/visual superposition diagram that depicts the letter "e" in **Fig. 10B**. This alignment reinforces, in the user's mind, the mapping between the control regions to be selected and the corresponding alphanumeric character. First, it does not introduce distractions and keeps the user focused on the task at hand (namely, indicating a desired character). Second, showing the stylized glyph so aligned is expected to help meet the user's expectations of her desired character being invoked. This may be particularly helpful when a character input panel before the user appears as a solid rectangle, with no outline that shows the boundaries of the control regions.

[0053] A process for constructing a desired character may be described as follows. First, when the user wants to generate a particular character, he or she recalls the corresponding, graphic symbol, as shown for example in **Fig. 7**. This graphic symbol then in turn suggests the regions or zones to be selected, namely those highlighted in **Fig. 7** or depicted in white in **Fig. 10A**. This forward process of construction in the mind of the user is symbolized in **Fig. 11A** for the example letter "K". However, the reverse is also true. When the user has selected the correct zone combination, the remainder of the selection area or matrix will look like the desired character, thus confirming for the user that he or she has selected correctly.

System Applications

[0054] **Fig. 11A** also depicts a user operating a handheld computing device 1104, such as a PDA device. As shown in block diagram form in **Fig. 11B**, the handheld device 1104 includes a data entry portion 1108 such as a touch-sensitive display screen in which a matrix of control regions have been

defined in a preferably flat, input control area 1112. Each of the control regions is sensitive to a force exerted by the user via his or her finger or via an input control instrument 1116 such as a stylus. In addition, the input control area 1112 may be superimposed with an input visualization area 1120 (or vice versa), so that each of the control regions can be visually contrasted with the remainder of the matrix when the user has selected the region. The visualization area 1120 also allows a graphic symbol, bearing either the 19 zone matrix 408 (see **Figs. 4-7**), a 12 zone matrix 808 (see **Fig. 8** and **Fig. 10A**), or another higher or lower resolution alternative, to be depicted when the control regions are selected by the user. Some type of portable power source, such as a rechargeable battery or a fuel cell (not shown) is provided in the PDA device, coupled to power the display screen as well as the logic which implements the character representation technique described above.

[0055] **Fig. 11B** also shows a separate character output display 1130, used for displaying the generated characters, either in the form of their respective graphic symbols or in a conventional, high resolution font. An alternative to this arrangement is to locate the input control area 1112 and the input visualization area 1120 so as to partially or even completely overlap with a part of the larger, character output display 1130 (see **Fig. 11C** where the input control and visualization areas 1112, 1120 (superimposed relative to each other) overlay a large portion of the output display 1130 where previously generated words and characters are simultaneously being displayed); this alternative may be especially useful for very small devices 1104 such as enhanced watches where display area is at a premium.

[0056] The device 1104 should preferably include further logic that is designed to control the touch sensitive display screen so that each respective combination of zones selected by the user is visually contrasted with the remainder of the matrix, as the operator selects the combination. This produces in effect a real-time sensation in the operator of drawing the desired character. Of course, as explained above, the operator does not actually draw a character in the matrix complement technique, but rather assembles it using the feature-based, complementary approach described above. It should be noted that the logic circuitry may include hardwired logic circuitry and/or a programmed

processor device having a machine-readable medium (such as random access memory 1128) with input control data and input visualization data stored therein that, when accessed by a microprocessor 1124, performs the matrix-complement approach described above using, for example, a table look-up to match a given input combination of control regions with a corresponding character and its graphic symbol.

[0057] Although the matrix-complement character generation concept described above can be applied in electronic systems having mechanical or virtual buttons as the selection controls, the preferred embodiment is implemented in touch-sensitive screen systems that also support touch-begin and touch-end (or also referred to as pen-down, PD, and pen-up, PU) events. Using such a technique, it has been found that each character can be identified by a single stroke of the pen or stylus on the touch sensitive screen. More specifically, the first region or zone is selected with a pen-down action, as shown in **Fig. 12A** for the 12-zone matrix. The second, and in this case the last, region is selected by a pen-up action. In between these two actions, the stylus can be moved about on the character-generating control matrix as desired (see the left-hand diagram of **Fig. 12A)**, without affecting the accuracy of the mapping between a combination of selected control regions and its corresponding alphanumeric character. In cases where the character is represented by a single region, the pen-down and pen-up actions remain on a single region (see the right hand diagram of **Fig. 12A**). Other possible applications for the matrix-complement techniques described above include desktop computer systems, automated teller machines, and mobile telephone devices where the control regions are typically represented by spaced apart (rather than abutting) mechanical pushbuttons on a keyboard or keypad. In such an embodiment, one or more key activation events may be prescribed for each character. For example, one or more keys may be associated with a given character, and an activation event for each key may be defined as the key being depressed or let go by the user. Note that the timing of the activation events for a given combination may not matter, if the combination of events is based on a combination of keys that is unique to each character.

[0058] Sometimes the user may want to undo the effect of a region selection action for a certain character, prior to beginning the process of indicating the next character. According to an embodiment of the invention in which the PU and PD actions are used for such region selection, the undoing or reversing process may be described as follows. First, the user performs an initial PD action upon a first region. The system then detects the first region. Next, the user slides the stylus out of the first region, without any PU actions. Now, if the stylus is then slid back to the first region (without any PU actions), and is then followed by a PU action off the first region, the system interprets the sequence as not invoking a character. In other words, to undo his actions, the user slides the stylus back to the first region that was selected by the initial PD action, and then lifts the stylus, to prevent a character from being generated.

Special Characters

[0059] There are some characters that may be too complex to be easily represented using only a combination of regions from the complement matrix 408 (see **Figs. 4-7**). There are also characters that look so similar to each other that a combination of selection regions assigned for one of them would also be suggested for the other. One solution for invoking these special characters, while using the same complement matrix defined above, is as follows. First, an association between a special character and a certain previously defined control region combination is made. For example, the character "@" looks like the letter "a" and hence may be associated with the same two-region combination assigned to "a". Similarly, the characters "[" and "{" may be associated with the two-region combination that is assigned to the letter "c". Alternatively, the character "{" can be associated with another similar looking special character, namely "<". This is also referred to as control region sharing by different characters, which are assigned the same base or initial set of regions. Next, to distinguish between two similar characters (that share the same initial set of control regions or code configuration), a special control region, which may be separate from the complement matrix or the control matrix, is defined that may be selected by the user to indicate one, and not the other, of the two similar characters.

[0060] A preferred approach to distinguishing between two similar looking characters, however, is to define a special movement of the user's finger or stylus, during the region selection process. For example, in the touch-sensitive screen embodiment, which may also support PU and PD events, a "swirl" action can be defined as sliding the stylus on the surface of the screen. The motion may be clockwise or counterclockwise, while staying within a given control region and without lifting the stylus off the screen. See **Fig. 12B**. The initial direction of motion, clockwise or counterclockwise, may be used as a differentiating factor. The number of swirl orbits, or partial orbits, detected by the system may also be used as differentiating factors (see **Fig. 12B** which illustrates a single, clockwise orbit, while **Fig. 12C** shows one and a half, counterclockwise orbits). For example, the number of swirl orbits or partial orbits that have been detected may serve to increment or decrement a selection counter, where post-initial swirl direction determines the increment/decrement action, and each count is used to indicate a different special character. A swirl may also be used to indicate an additional control option (e.g., begin or stop capitalize, begin or stop bold face, insert a space, etc.).

[0061] The swirl may be applied in the final selection region of a given code configuration, to allow the user to cycle through viewing the initial character and then the different special characters that bear some resemblance to the initial character. Note that all of these special characters share the first and second selection regions, but can now be differentiated using the swirl action. Another way to explain this effect is to consider that several special characters can share the same code configuration of a base character, i.e., the same initial combination of one or more control regions to be selected that have been assigned to the base character, and the swirl action distinguishes beyond this initial code. For example, in **Fig. 12D**, the character "[" has been invoked by selecting the regions 1275 and 1277 (which , without more, represents a default code configuration , namely that of lower case "c"), followed by a single (1) swirl. Making an additional swirl (2) results in the character "{" being invoked (see **Fig. 12E**). To make the choices more clear, the corresponding graphic symbols or pictograms (which may be given additional detail as needed to resemble their corresponding characters) are superimposed onto the

control matrix as shown. Note that stepping backwards and forward through the possible characters may be accomplished by reversing the direction of the swirl.

Additional Embodiments

[0062] Turning now to **Fig. 13A**, another embodiment of the invention is illustrated as another set of graphic symbols that correspond to the 36 alphanumeric characters. In this embodiment, each receiving area 1304 is of a contrasting color with respect to its background 1306, with a peripheral boundary 1307 shown in a darker color. Each receiving area 1304 is to receive a combination of one or more marks that represents the desired alphanumeric character. Each mark has a given form, position, and orientation within the receiving area 1304, that suggest a feature of the character, once again through a complementary rather than direct relationship with that feature. Taking the letter "a" as an example, the receiving area 1304 for that letter bears a mark 1312 being a dot positioned in the lower half of the rectangular receiving area 1304, where the dot refers to the feature of a below-center closed curve 132 (see **Fig. 1**). The mark 1312 is also used for representing other characters such as "b" and "d" as shown.

[0063] A second mark 1310 is needed to define the graphic symbol for the letter "a" shown in **Fig. 13A.** The mark 1310 is a straight line that is pointing upwards and to the right, and is positioned in a left half of the receiving area 1304. This mark 1310 refers to the feature of an above-center curve opening to the left 139 (see **Fig. 1**). It can be seen that the combination of the marks 1310 and 1312, when viewed on the receiving area 1304 which is contrasted with its background 1306, suggests to a person that the receiving area 1304 is referring to the letter "a". Note that the straight lines may alternatively be angled differently, slightly curved, or they may be substantially horizontal, and still be capable of visually depicting the letter "a".

[0064] The inventor has found that a generic receiving area template or "matrix" 1328 with a rectangular shape (including top, middle, and bottom non-overlapping regions), as shown in **Fig. 13B**, may be used to represent each of the 36 alphanumeric characters, using a combination of only straight lines

and dots (such as the marks 1310 and 1312). The matrix 1328 in **Fig. 13B** shows all of the possible marks in this embodiment, namely two dots and 18 straight lines, in various positions and orientations as shown. This embodiment of the invention may be more effective where the user is to indicate each character in a separate receiving area, as if a word were being written on a sheet of paper. The border 1307 (see **Fig. 13A**), and the contrasting colors of the receiving area 1304 and the background 1306 may be preprinted or pre-displayed on a form, and the user is then instructed to indicate the desired character by simply making the marks being a dot or a straight line. A word spelled using the graphic symbols of **Fig. 13A** is shown in **Fig. 14**. It is noted that when forming words and phrases based on the graphic symbols depicted in **Fig. 13A**, none of the marks that are to be made by the user to indicate the characters form a closed shape.

[0065] It is expected that the user can quickly learn the combination of dots and/or lines that represent each character, as shown in the embodiment of **Fig. 13A**, by recognizing or recalling the complement-matrix approach described above. The orientation and location of each dot and/or line for a given character is suggested by one or more features of the character, which should be apparent to the user. For example, if the user wants to enter the character "3", the user should recall that this character can be decomposed into an upper curve opening to the left and a lower curve opening to the left, stacked. This will immediately suggest that two substantially horizontal lines, one substantially in the upper half and another substantially in the lower half, need to be marked, at the left side of the receiving area 1304, so that the resulting graphic symbol will resemble the number "3".

[0066] To summarize some embodiments of the invention, a novel character representation or coding technique has been described that is easy to learn. Rather than have the user positively draw or define the features of a character, the user is instead instructed to positively indicate (or manually apply force) to those regions that are the complement of one or more features of the character. For example, rather than have the user draw the entire contour of a plane closed curve (as in the letter "o"), the user contacts a point in a control region that is understood as representing the inside of the plane

closed curve. It is then up to the electronic device, or other mechanism, to reflect the visual contrast needed to highlight the actual features of the desired character, based on the complement selection (e.g. visually contrasting the entire control region relative to its surrounding control regions). Other embodiments have also been described and claimed.

[0067] In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. For example, although the invention has been described in the context of English alphanumeric characters, the complement approach may also be applied to encode the characters of other languages. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.